Planar Technology for NDT-Ge X-Ray Microcalorimeters: Absorber Fabrication

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Abstract. We have investigated the electroplating process to deposit thick uniform films of tin on a Ge wafer coated with Spin-On Glass, in order to fabricate the absorbers for Ge microcalorimeter arrays. Here we discuss some technological details and propose two alternative metal bilayer to be used as seed for the electroplating.

Keywords: Microcalorimeter array, NTD-Ge, Absorber, Planar Technology.

INTRODUCTION

We are developing a planar technology to build sensors and absorbers for NTD-Ge X-Ray microcalorimeter arrays [1][2][3]. A superconducting Sn absorbing layer, about 10 microns thick, is grown by electroplating onto a germanium wafer previously coated with a thin dielectric film and a metal seed. The individual sensor pixels with proper geometry are then obtained by chemical etching from the germanium wafer. The technological steps are shown in Fig.1. More details about the whole process can be found in [4].

Uniformity among the absorbers is crucial for the performances of microcalorimeter arrays. To have a good repeatability the thermal conductance to the sensor and the heat capacity must be the same for all the absorbers.

ABSORBERS FABRICATION

The thickness required for the absorbers to effectively block the incident X-rays, ~ 10 µm for 6 keV photons, is incompatible with the traditional techniques of thin film deposition by evaporation or sputtering. Electroplating instead is a process suitable to provide uniform thick films. The purity of the films obtained, intrinsically very high, may be reduced in a controlled manner by introducing impurities into the bath. For the tin, a control on purity allows to obtain films not affected from the "tin pest".

Insulating Layer and Metallic Seed

Before the tin can be grown, an electrically insulating layer and a metal film have to be deposited on the germanium.

The purpose of the dielectric coating on the Ge wafer is to prevent the short-circuit of the germanium sensor through the absorber. To obtain this insulating layer we used Spin-On Glass (SOG), silicic acid suitable for spin deposition. Once subjected to a proper heat treatment, the SOG hardens and assumes properties similar to those of silicon dioxide. After curing, SOG volume decreases due to evaporation of the solvent and molecular reorganization; the film is then subjected to a slight tensile stress which is beneficial since it is opposed to the compressive stress present at low temperatures because of the difference in the coefficient of thermal expansion heat between SOG and germanium. We used SOG 20B from Filmtronics, spinned for 15” at 3000 rpm and cured at 400 °C. Nominal thickness is 250 nm.

The metal film is the seed for the electroplating and allows the plating current to circulate. The choice of the metal layer must take into account the following points:

- Adherence on SOG.
- Compatibility with the electroplating process.
- Low heat capacity.

Choice of Metal Layer

The first tests have been performed on chromium, which has a good adherence to the SOG. However, the electroplating process for the tin growth causes the dissolution of the chromium (Fig. 2).

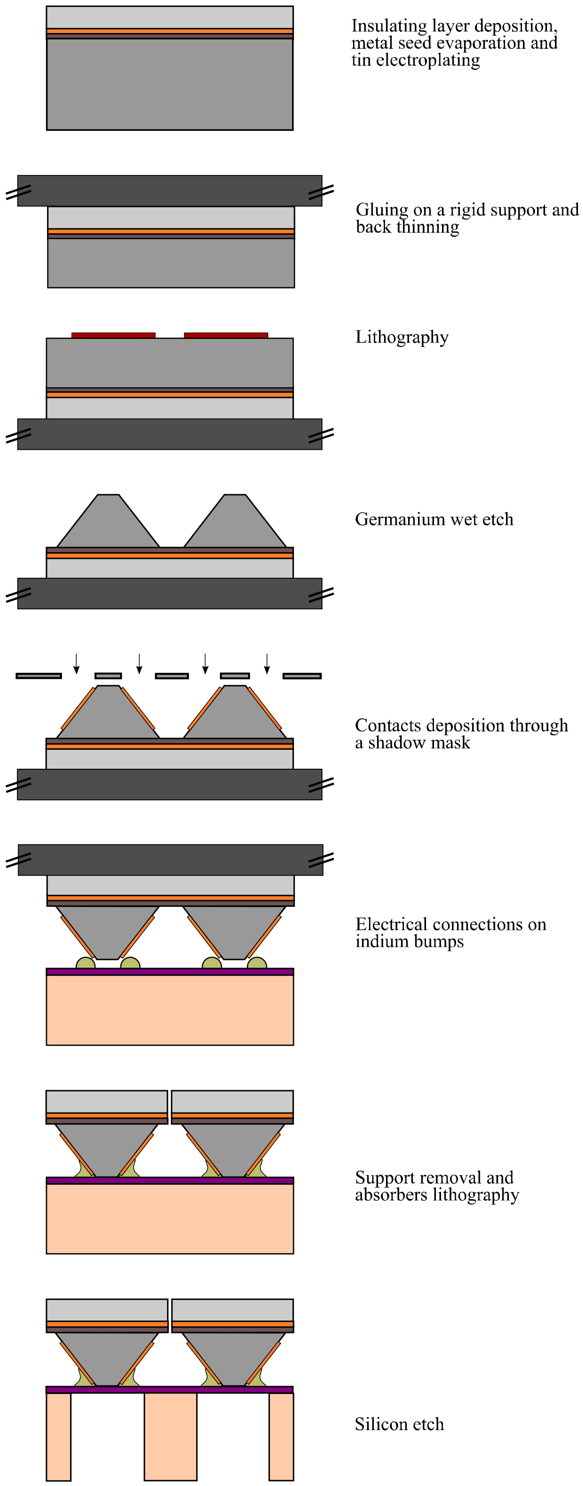

FIGURE 1. Schematic view of the main steps of the adopted planar process.

It was then tested a bilayer consisting of chromium and copper. Copper is compatible with the plating process and, while it does not adhere well to the SOG, it has excellent adhesion to chromium. Chromium, when protected by copper, is not subject to dissolution. However, along the edges of the bilayer, where chromium is not laterally protected by the copper, the metal is etched from the side, causing a lift-off of the copper and the growing tin deposit. Similarly, any defect in the copper film which leaves chromium exposed, caused for example by contamination during the evaporation, causes the dissolution of chromium with subsequent lift-off of copper and tin and leads to formation of bubbles (Fig. 3).

FIGURE 2. Tin plating on chromium: Cr was dissolved and the deposit is inconsistent.

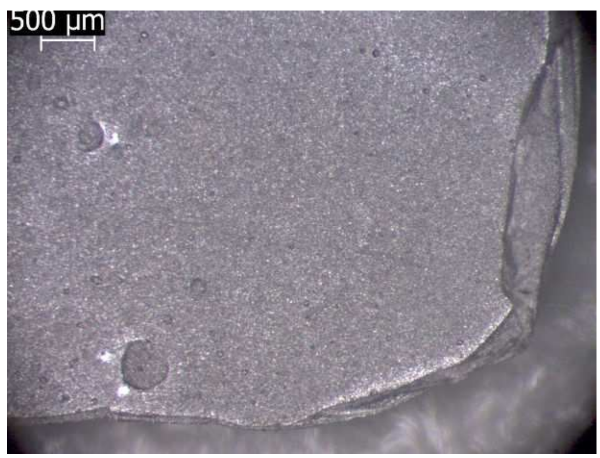

FIGURE 3. Tin plating on Cr+Cu: along the borders and where there were defects in Cu evaporation, the chromium was dissolved and there was a lift-up of the copper and the grown tin.

To minimize the problem we have experimented a procedure for oxidating the bilayer to protect the chrome exposed. Cr and Cr+Cu film samples were dipped in a solution of hydrogen peroxide at 30% for

10 minutes. The samples were then used as electrodes in the tin plating bath. The electroplating was performed with a current density of 0.1 mA/mm^2, with a bath composed by 1l H_2O_2 + 100 g $K_2Sn(OH)_6$ + 15 g KOH. The oxidized chromium resisted the electroplating process (Fig. 4). The oxidation of copper film, on the other end, was not an obstacle for the tin deposition because the oxide was immediately removed during the electrochemical reaction. Fig. 5 shows the tin deposit obtained on a Ge wafer coated with SOG, 10 nm of Cr, 90 nm of Cu, where the sandwich surface was treated with the oxidating solution.

FIGURE 4. Tin plating on oxidized Cr: the chromium was not dissolved; there are traces of tin deposit on the surface.

FIGURE 5. Tin plating on Ge + SOG + Cr + Cu treated with hydrogen peroxide: the deposit is uniform and defect free.

Another pair of metal to form the bilayer has been identified, which promises several advantages: Ti+Au.

- Titanium deposited by evaporation has an excellent adhesion to glassy materials.
- Ti is not damaged during the electroplating process.
- Ti is superconductor so it has a low heat capacity at cryogenic temperatures.
- Gold deposited by evaporation adheres well to titanium.
- Au is a noble metal, so it is less prone than copper to the formation of unwanted compounds on the surface.
- Electroplated tin grows well on gold and is adherent and uniform.

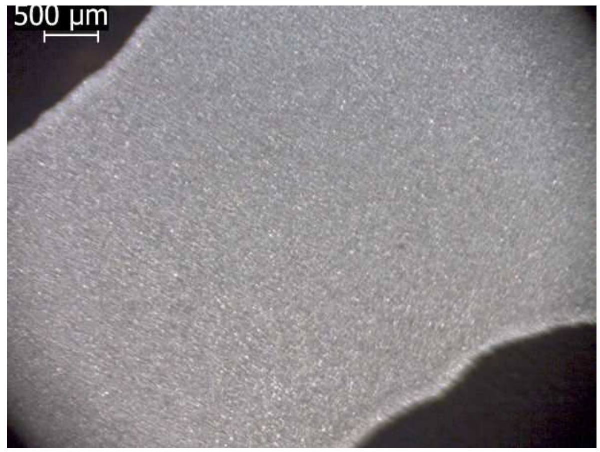

FIGURE 6. Tin plating on Gold (Au pad on a PCB): the deposit is uniform.

CONCLUSIONS

We have explored different materials as electroplating seeds and propose two alternative metallic bilayers. Cr+Cu presents some problems that can be overcome with the described oxidation technique. Ti+Au promises several advantages and will be further investigated.

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